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(JOINT SESSION OF THREE BRANCHES)

Conference Report

by

G. B. Zhdanov

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RADIATION BELTS AND COSMIC RAYS

(JOINT SESSION OF THREE BRANCHES)

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SUMMARY

This report describes the various topics of discussion during the joint session of the branches of general and applied physics, nuclear physics and Earth's sciences, held on 4 — 5 February 1965, and especially devoted to Earth's radiation belts and to the physics of cosmic rays.

author

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The balance sheet of the basic experimental investigations of radiation belts was lately drawn in the review by S. N. Vernov.

The most important of the results obtained is the detection of peculiar acceleration processes acting in the outer Earth's sheath upon the electrons as well as protons. This direction already appears today as quite promising in connection with the broad possibilities of direct experimental investigations aboard rockets and satellites.

The reporter brought up schemes of spatial distribution of electron and proton components of radiation belts (the so-called electronosphere and protonosphere, respectively). Particularly emphasized were the zones containing the most energetic parts of the energy spectrum of electrons (>0.5 Mev) and protons (>30 Mev). The origin of these zones cannot be explained without resorting to acceleration processes.

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* RADIATSIONNYYE POYASA I KOSMICHESKIYE LUCHI (Sovmestnaya sessiya trekh otdeleniy).

A more detailed analysis of the spatial distribution of the various portions of the proton spectrum allows to speak in terms of the presence of radial relief (across the magnetic lines of force of the magnetosphere), accompanied by betatron acceleration of such particles, in agreement with the B. A. Tverskoy's calculations expounded in the course of the same session.

Interesting data on the longitude dependence of the particle flux intensity were obtained during the study of the Brazilian anomaly of cosmic rays, which plays the role of peculiar particle escape from the radiation belt.

For the understanding of particle acceleration processes in the belts a specific value is ascribed to the investigation of intensity variations. One of such types of variations is the very brief burst of particle flux intensity (~ 0.1 sec.), the other is the sporadic occurrence, during a lapse of time of the order of a day, of an additional, outermost belt, linked with the formation of a powerful ring current, with a current force in it of the order of 10^5 a.

When conducting various experimental investigations in the zone of radiation belts, the study of the action of large radiation doses ($> 10^6$ rad.) on optics, the polymer materials, the semiconductor and other physical apparatus, acquires a great importance.

A report by B. A. Tverskoy was devoted to the intricate complex of electromagnetic phenomena in the rarefied plasma of radiation belts. Considered in particular were such phenomena as the particle "run out" from radiation belts in the underlying layers of the outer atmosphere on account of Lorentz forces (the so-called "magnetic scattering") anomalous diffusion of particles during quick-passing magnetic storms linked with the action of solar corpuscular streams and so forth. The reporter ventured the interesting idea of possible utilization of analogous processes in laboratory conditions to obtain hot plasma clusters.

In a short communication K. I. Gringauz brought up the results of investigations of the properties of the third, outermost radiation

belt, characterized by a still greater intensity of corpuscular radiation, but, per contra, by a considerably lower energy of particles (hundreds of electronvolt).

The questions concerned with processes of generation of the solar component of cosmic rays were reviewed in a report by A. N. Charakhchyan, who analyzed, in cooperation with his coworkers, the results of more than 7000 stratosphere "expeditions" with an automatic apparatus raised on balloons at various latitudes. It was established, in particular, that the mean power of cosmic ray generation on the Sun is of the order of 10^{23} erg/sec, which yields by 18 orders to the power of the cosmic "generator" of the Galaxy as a whole.

The phenomenon of a sharp "softening" of the energy spectrum during magnetic storms with sudden commencement has been traced, and found to be connected, according to the reporter, with the arrival of radiation, captured by the magnetic traps of corpuscular streams.

The various astrophysical aspects of the physics of cosmic rays were expounded in the review by V. L. Ginzburg. Lately, the estimates of the mean path, covered by the galactic cosmic radiation, were made more precise, and on that basis the age of the radiation itself was estimated to be of $\sim$300 million years. The good agreement (with a precision to the factor of $\sim$2) between the direct data on electrons in the composition of primary cosmic rays and the radioastronomical data on the intensity of the synchrotron emission of electrons in the Galaxy, is of great importance for the understanding of particle acceleration processes in the Galaxy. Very essential for the clarification of the origin of the electron component was found to be also the first experimental estimate of the ratio of the number of electrons and positrons (lower limit 6 : 1).

A serious discussion sprang up in regard to the question of the role of supernovae as the main source of cosmic rays in the Galaxy. According to I. S. Shklovskiy, it has now become clear, that the energetic power of the aggregate of supernova bursts is apparently by one to two orders less than that required for the "pumping" of balanced intensity of cosmic rays.

At the same time, the possibility should not be excluded of the existence of a source of cosmic rays, such as the intergalactic space, earlier considered as little probable, but on the condition, however, that their angular distribution in the Metagalaxy be endowed with strong anisotropy. The metagalactic hypothesis of cosmic rays is closely linked with the just as important question of cosmogony, of the origin of magnetic fields in the Galaxy itself.

The experimental data on the inelastic nuclear interaction of cosmic rays with the matter were summed up in the review by N. A. Dobrotin. It was noted, that at feeble logarithmic dependence of all the mean characteristics of interaction on the initial energy E_0 (the inelasticity factor, the multiplicity, the angular distribution) a great scattering of the the same characteristics takes place in individual events (for a given E_0), and this apparently somehow reflects the inner structure of the strongly interacting particles.

In the course of the latest years interesting data on the distribution of inelasticity factors and on the great probability of asymmetric (relative to the angle $\theta = 90^\circ$ in the inertia center system) angular distributions, obtained in the experiments with an ionization calorimeter, assuring a reliable determination of the energy E_0, have been carefully analyzed in the Institute of Physics in the name of Lebedev. Currently, still more up-to-date installations of identical type became operational in the Tien-Shan and Georgia.

Cases with anomalously high inelasticity factors (the energy liberation into π^0-mesons constitutes $\geqslant 2/3 \cdot E_0$) were revealed and studied by N. L. Grigorov and his coworkers at the scientific station on the mountain Aragats (Armenia) with the help of an installation including a series of ionization chambers and photoemulsions. These data are interpreted by the authors from the viewpoint of hydrodynamic-type processes, linked with central interactions (as distinct from the asymmetric interactions, of peripheric type, as a rule).

A series of interesting data was contributed during the latest years by the study of extensive air showers of moderate energies (from 10^{13} to 10^{16} eV). Established in particular was the very feeble dependence

of the interaction cross section of particles on E_o and the peculiar phenomenon of narrow beam formation of μ— mesons with energies to 10^{13} eV; indications were also obtained on the character variation of elementary interaction at energies of the order of 10^{14} eV.

The remark by the reporter on the presence of hydrodynamic-type processes triggered an animated discussion. One of the speakers, N. L. Grigor'yev, called attention to the importance of further investigations of the nature and origin of the most energetic products of nuclear interaction.

The review of theoretical works along the same lines was made by E. L. Feynberg. He noted a series of theoretical forecasts, subject to practical verification, on simplest elementary formations with fractional charges, but perhaps still unknown, perhaps very large mass, for example. The important problem is the establishment of a deep inner link between the character of elastic and inelastic processes, in particular of the connection between the narrowing of the diffraction maximum with rise of energy, with the prevalence of interaction of peripheral type. This verification should also concern the forecast of the possibility of emergence of resonance states of a large mass (fireball type), whose distribution by masses are independent from the energy E_o, but, per contra, the quantity (in a single interaction) can substantially increase with the rise of E_o.

The session, as a whole, has shown a great fruitfulness of joint discussion of the problems concerning the radiation belts and cosmic rays by representatives of a series of borderline areas — astrophysicists, astronomers, geophysicists and specialists of elementary particles and neutrino physics, on terrestrial magnetism and plasma.

*** THE END ***

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